California High-Speed Train Project

Request for Proposal for Design-Build Services

RFP No.: HSR 11-16
Geotechnical Data Report
Clinton Ave to East American Ave

Appendix D
PS Logging Records – Geovision Geophysical Services

Prepared for

CALIFORNIA High-Speed Rail Authority

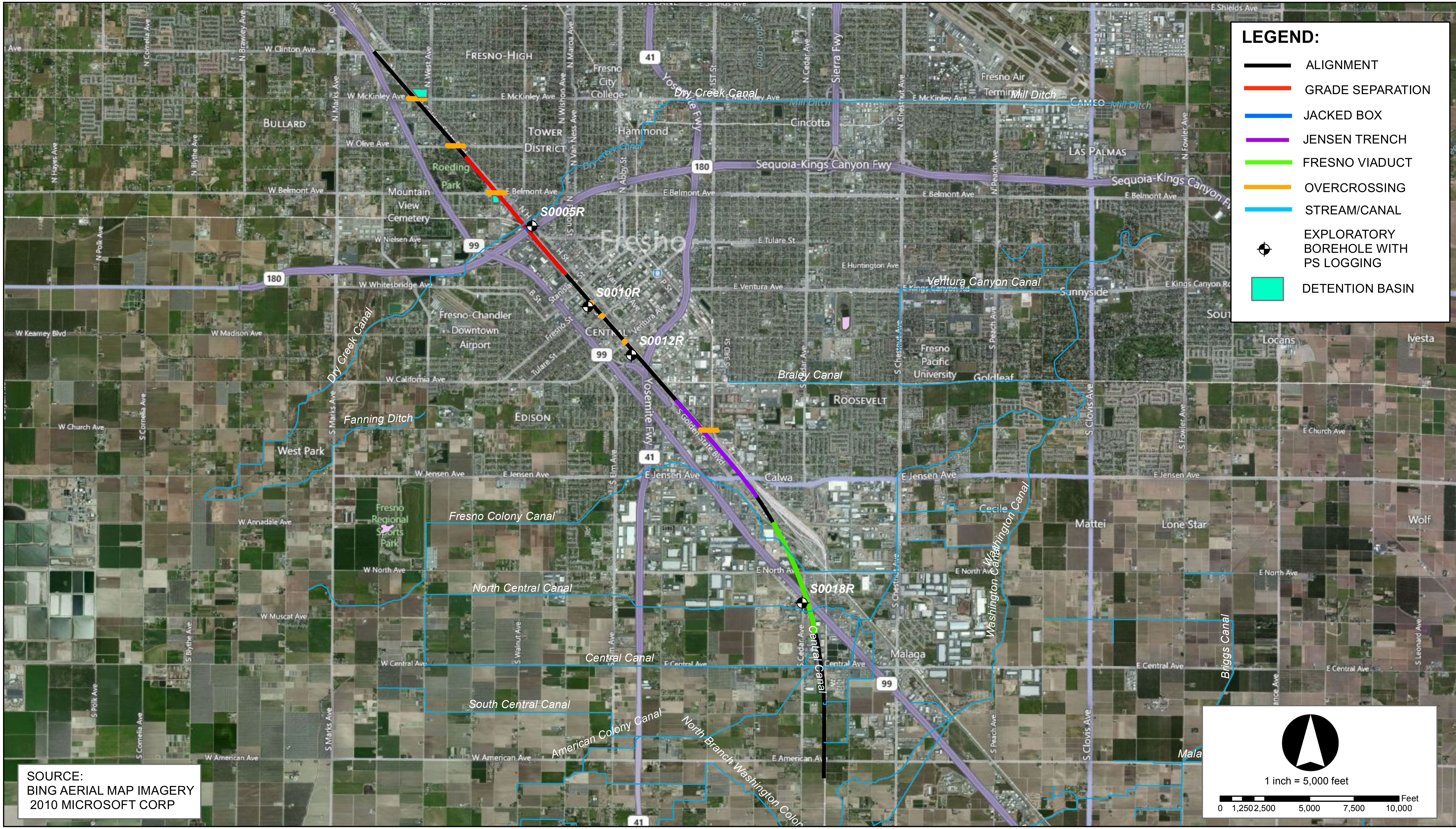
Appendix D

PS Logging Records —
GEOVision Geophysical Services

Table D-1
Summary of PS Logging Locations, Depths, and Dates Logged

Borehole ID	Date Logged	Elevation (NAVD88) (ft)	Northing (NAD83) (ft)	Easting (NAD83) (ft)	Depth Interval[1]	
					Top Depth (ft)	Bottom Depth (ft)
S0005R	10/17/2011	285.30	2,155,457	6,325,239	6.6	82
S0010R	10/19/2011	286.10	2,150,922	6,328,342	6.6	152.6
S0012R	10/25/2011	287.60	2,148,215	6,330,774	1.6	150.9
S0018R	10/28/2011	305.80	2,134,428	6,340,369	26.3	149.3

[1] Logging performed at 1.6 foot intervals between top and bottom depths



MAP OF EXPLORATORY BOREHOLES WITH PS LOGGING
California High Speed Train
Fresno to Bakersfield
Geotechnical Data Report - Package 1

Figure No. D1
February 2012

CALIFORNIA HIGH SPEED TRAIN
FRESNO TO BAKERSFIELD,
BORINGS S0005R, S0010R, S0012R
AND S0018R VELOCITIES

Report 11349-03 Rev 1

February 1, 2012

CALIFORNIA HIGH SPEED TRAIN
FRESNO TO BAKERSFIELD,
BORINGS S0005R, S0010R, S0012R
AND S0018R VELOCITIES

Report 11349-03 Rev 1

February 1, 2012

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APPENDICES

APPENDIX A **SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS**

APPENDIX B **GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION RECORDS**

INTRODUCTION

Boring geophysical measurements were collected in four uncased borings located along the proposed alignment of the California High Speed Train, in Fresno, California. Geophysical data acquisition was performed on October 17, 19, 25 and 28, 2011 by Victor Gonzalez, Robert Steller and Charles Carter of **GEO***Vision*. Data analysis and report preparation was performed by Robert Steller and reviewed by John Diehl of **GEO***Vision*. The work was performed for ARUP, under subcontract with Gregg Drilling & Testing, Inc. (Gregg). Chris Christensen served as the point of contact for Gregg and Brandon Kluzniak served as the point of contact for ARUP.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected on October 17, 19, 25 and 28, 2011, in four uncased borings, as detailed below. The purpose of these studies was to supplement stratigraphic information obtained during ARUP's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING	DATES LOGGED	ELEVATION [1] (NAVD88, FEET)	COORDINATES (FEET) [1]	
			NORTHING	EASTING
S0005R	10/17/2011	285.26	2,155,457.49	6,325,238.59
S0010R	10/19/2011	286.12	2,150,921.78	6,328,341.74
S0012R	10/25/2011	287.57	2,148,215.47	6,330,773.97
S0018R	10/28/2011	305.75	2,134,428.02	6,340,369.12

(1) Coordinates provided by ARUP

Table 1. Boring locations and logging dates

The OYO Suspension PS Logging System (Suspension System) was used to obtain in-situ horizontal shear (S_H) and compressional (P) wave velocity measurements at 1.6 foot intervals. Measurements followed **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.5. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the suspension PS velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed below the surface casing using the Suspension PS logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 21 feet, with the center point of the receiver pair 12.5 feet above the bottom end of the probe.

The probe receives control signals from, and sends the digitized receiver signals to, instrumentation on the surface via an armored 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in

turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and S_H-wave signals.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H-wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe (meter versus centimeter scale), preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

The borings were logged while filled with bentonite or polymer based drilling mud. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.5. The probe was positioned with the mid-point of the receivers at ground level, and the depth value was set to zero, in order to reference all depths to ground level. The probe was lowered to the bottom of the boring, stopping at 1.6 foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	OPEN HOLE (FEET)	DEPTH TO BOTTOM OF CASING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
S0005R	SUSPENSION 1	6.6 – 82.0	94.5	5	1.6	10/17/2011
S0010R	SUSPENSION 1	6.6 – 152.6	165.1	5	1.6	10/19/2011
S0012R	SUSPENSION 1	1.6 – 150.9	163.5	NONE	1.6	10/25/2011
S0018R	SUSPENSION 1	26.3 – 149.3	161.8	25	1.6	10/28/2011

- PROBE DID NOT TOUCH BOTTOM OF BORING

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based upon the arrival time picks made in PSLOG.

The P-wave velocity over the 7.0-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 5.2 feet to correspond to the mid-point of the 7.0-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 4 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering was used to remove the higher frequency P-wave signal from the S_H-wave signal. Different filter cutoffs were used to separate P- and S_H-waves at different depths, ranging from 600 Hz in the slowest zones to 2000 Hz in the regions of highest velocity. At each

depth, the filter frequency was selected to be at least twice the fundamental frequency of the S_H-wave signal being filtered.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 7.0-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 5.2 feet to correspond to the mid-point of the 7.0-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 4 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact. These data and analysis were reviewed by John Diehl as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4 through 7. The suspension velocity data presented in these figures are presented in Tables 3 through 6. These plots and data are included in the EXCEL analysis files accompanying this report.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-4 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 7.0 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-4, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in uncased fluid filled borings, drilled with rotary mud (rotary wash) methods. These borings were ideal for collection of suspension PS velocity data.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1 data, as well as good correlation between P-wave and S_H-wave velocities. P-wave and S_H-wave onsets are generally clear, and later oscillations are well damped.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. Individual measurements are very reliable with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of these data.

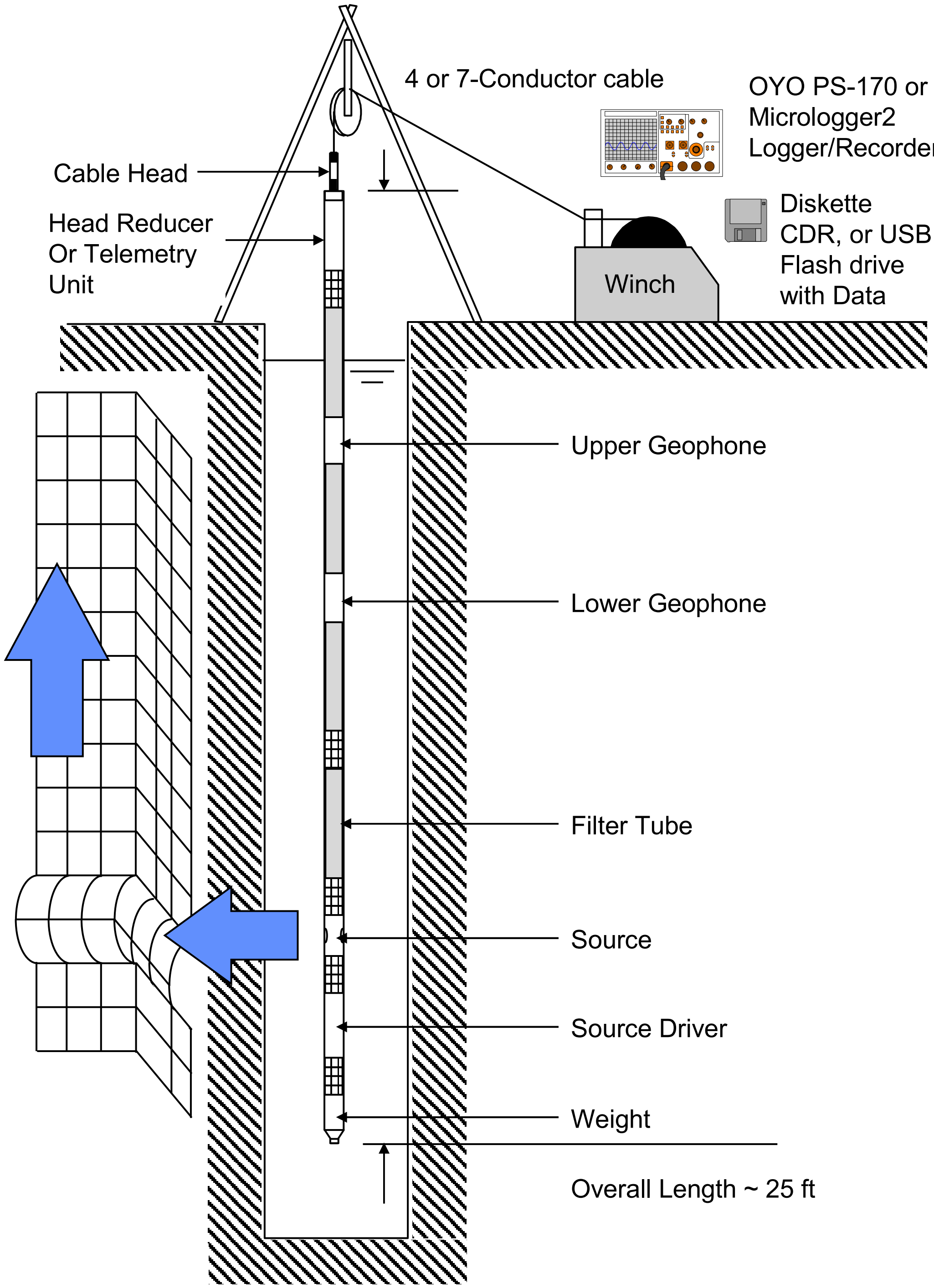

Figure 1: Concept illustration of P-S logging system

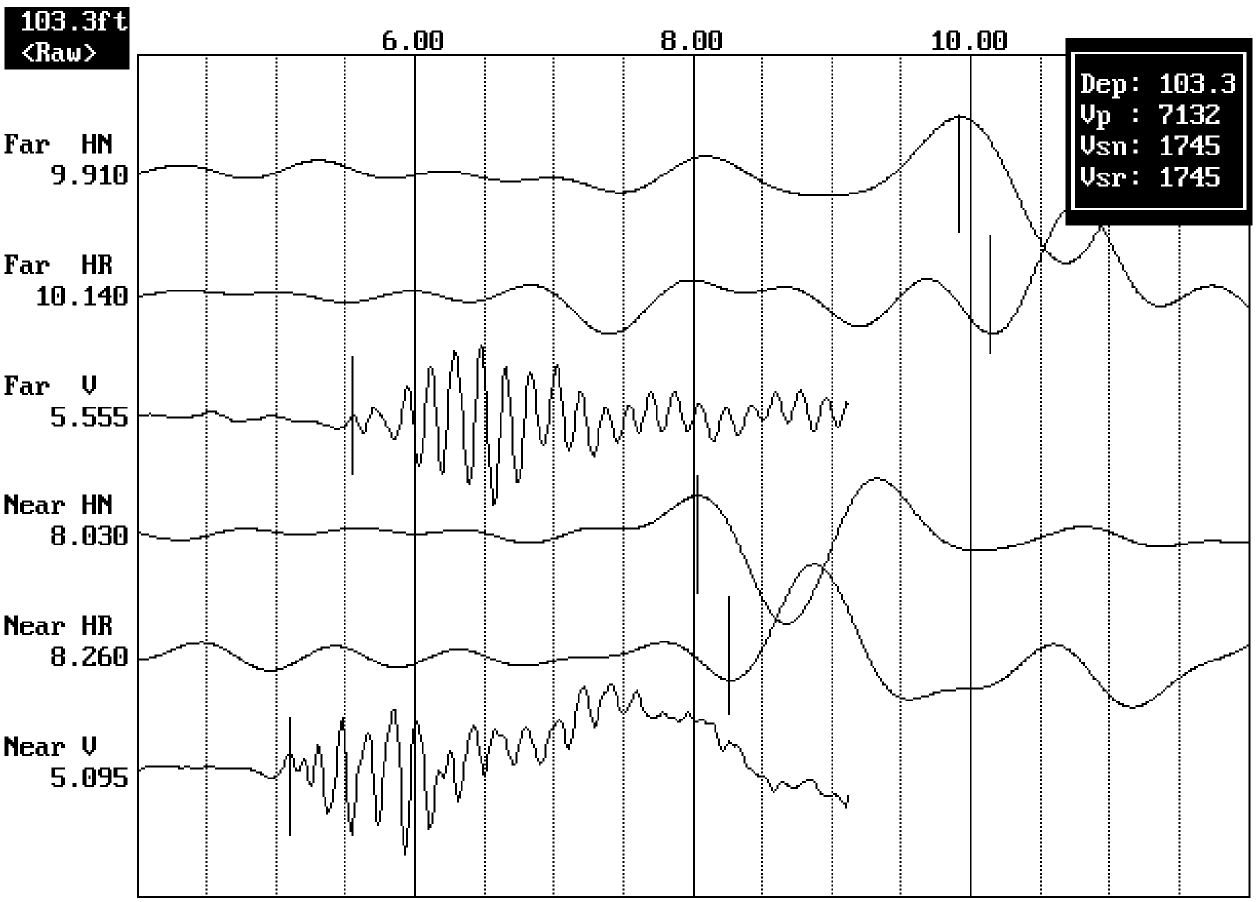

Figure 2: Example of filtered (1400 Hz lowpass) record

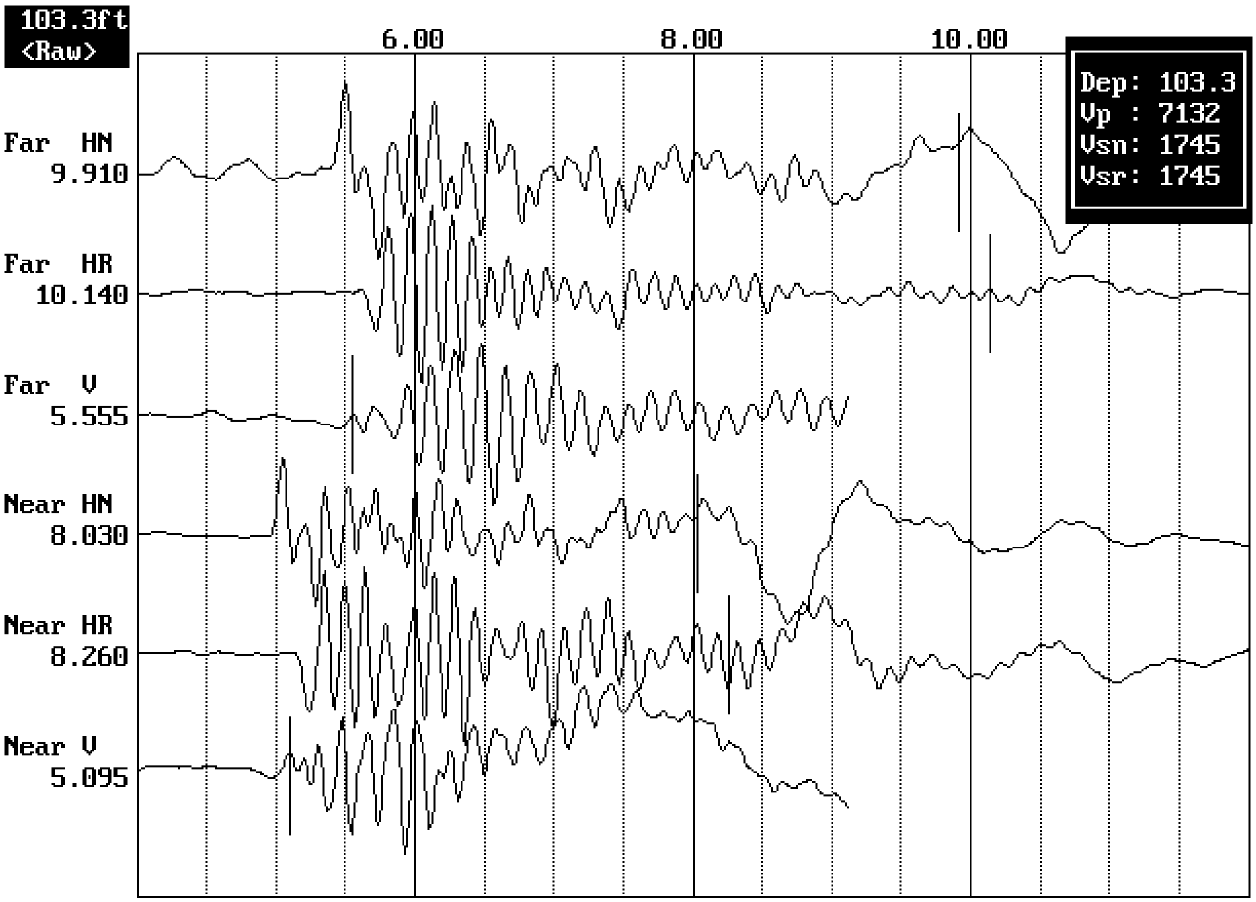

Figure 3. Example of unfiltered record

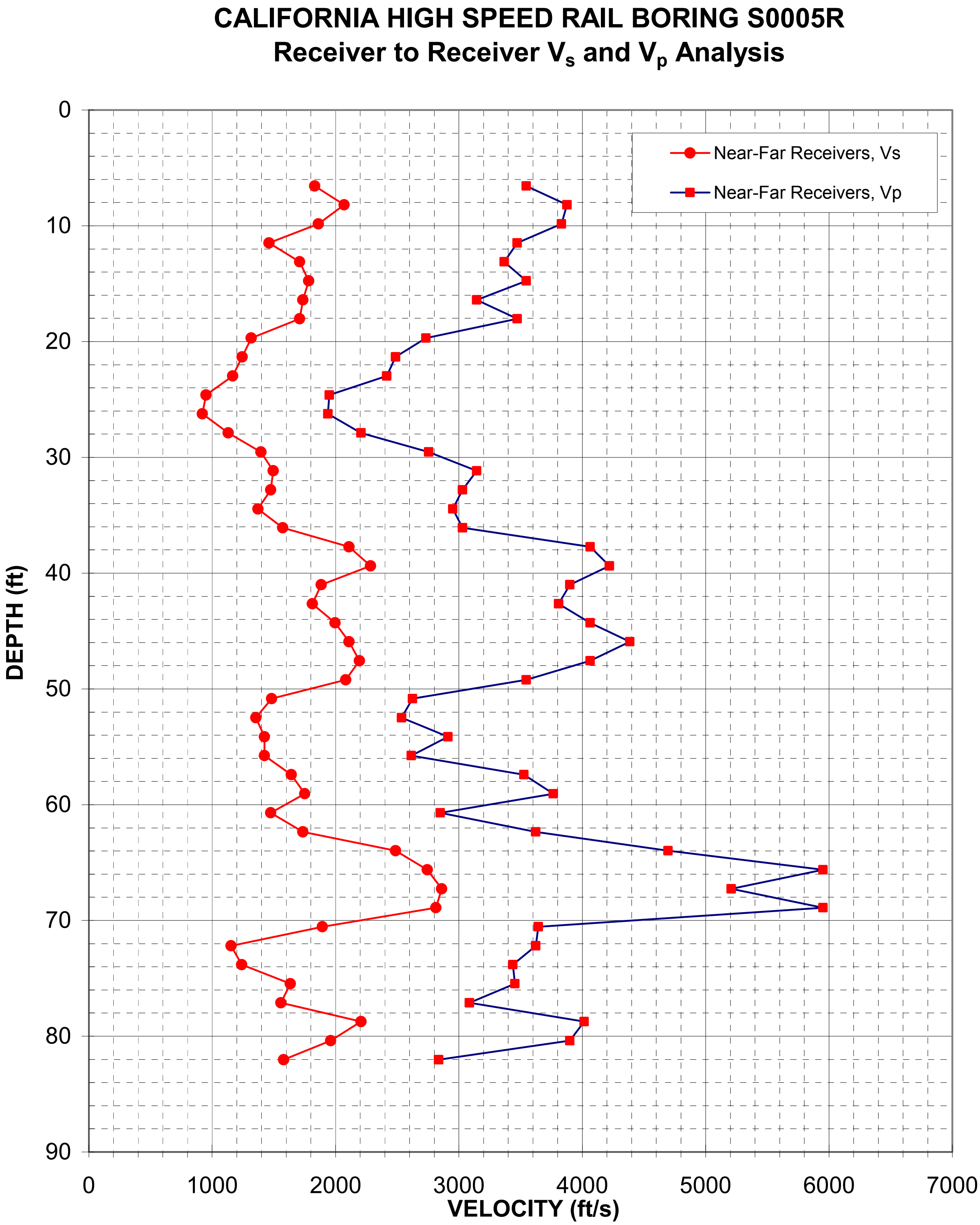

Figure 4: Boring S0005R, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
6.6	1830	3550
8.2	2070	3880
9.8	1860	3830
11.5	1460	3470
13.1	1710	3370
14.8	1780	3550
16.4	1740	3140
18.0	1710	3470
19.7	1320	2730
21.3	1240	2490
23.0	1170	2420
24.6	950	1950
26.3	920	1940
27.9	1130	2210
29.5	1390	2750
31.2	1490	3140
32.8	1470	3030
34.5	1370	2950
36.1	1570	3030
37.7	2110	4070
39.4	2280	4220
41.0	1880	3900
42.7	1810	3810
44.3	2000	4070
45.9	2110	4390
47.6	2190	4070
49.2	2080	3550
50.9	1480	2620
52.5	1360	2530
54.1	1420	2910
55.8	1420	2610
57.4	1640	3530
59.1	1750	3770
60.7	1470	2850
62.3	1740	3620
64.0	2490	4690
65.6	2740	5950
67.3	2860	5210
68.9	2810	5950
70.5	1890	3640
72.2	1150	3620
73.8	1240	3440
75.5	1630	3450
77.1	1560	3090
78.7	2210	4020
80.4	1960	3900
82.0	1580	2840

Table 3. Boring S0005R, Suspension R1-R2 depths and P- and S_H-wave velocities

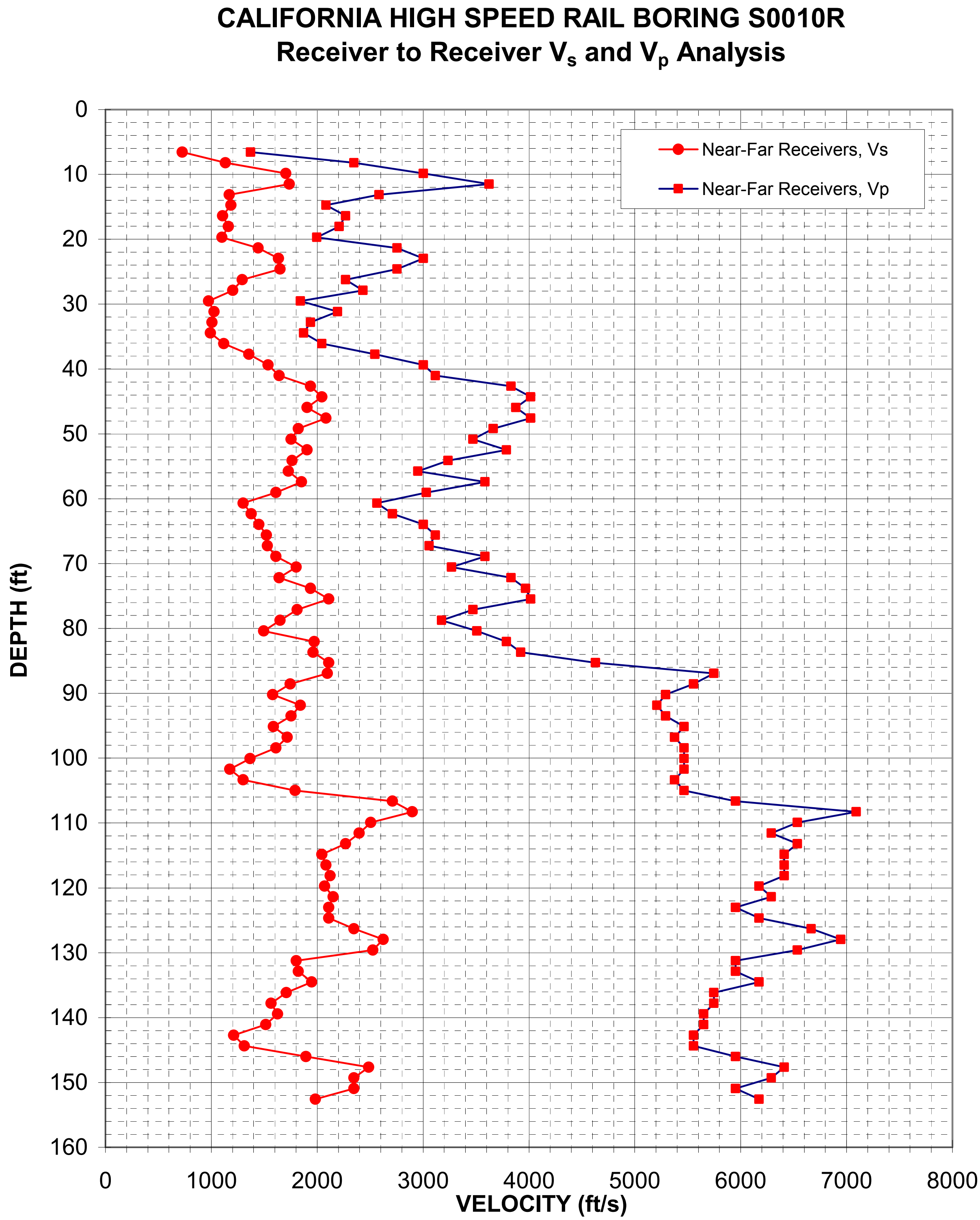

Figure 5: Boring S0010R, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
6.6	720	1370
8.2	1130	2350
9.8	1710	3000
11.5	1740	3620
13.1	1170	2580
14.8	1190	2080
16.4	1110	2270
18.0	1160	2210
19.7	1100	2000
21.3	1440	2750
23.0	1630	3000
24.6	1650	2750
26.3	1290	2270
27.9	1200	2430
29.5	970	1840
31.2	1030	2190
32.8	1010	1940
34.5	990	1870
36.1	1120	2040
37.7	1360	2540
39.4	1540	3000
41.0	1640	3120
42.7	1940	3830
44.3	2040	4020
45.9	1900	3880
47.6	2080	4020
49.2	1820	3660
50.9	1750	3470
52.5	1900	3790
54.1	1760	3240
55.8	1730	2950
57.4	1850	3580
59.1	1610	3030
60.7	1300	2560
62.3	1380	2710
64.0	1450	3000
65.6	1520	3120
67.3	1530	3060
68.9	1610	3580
70.5	1800	3270
72.2	1640	3830
73.8	1940	3970
75.5	2110	4020
77.1	1810	3470
78.7	1650	3170
80.4	1490	3510
82.0	1970	3790
83.7	1960	3920
85.3	2110	4630
86.9	2100	5750
88.6	1750	5560
90.2	1580	5290
91.9	1840	5210
93.5	1750	5290
95.1	1590	5460
96.8	1720	5380
98.4	1610	5460
100.1	1370	5460
101.7	1170	5460
103.4	1300	5380
105.0	1790	5460
106.6	2710	5950
108.3	2900	7090
109.9	2510	6540
111.6	2400	6290
113.2	2270	6540
114.8	2040	6410
116.5	2080	6410
118.1	2120	6410
119.8	2070	6170
121.4	2150	6290
123.0	2110	5950
124.7	2110	6170
126.3	2350	6670
128.0	2620	6940
129.6	2530	6540
131.2	1800	5950
132.9	1820	5950
134.5	1950	6170
136.2	1710	5750
137.8	1560	5750
139.4	1630	5650
141.1	1520	5650
142.7	1210	5560
144.4	1310	5560
146.0	1890	5950
147.6	2490	6410
149.3	2350	6290
150.9	2350	5950
152.6	1980	6170

Table 4. Boring S0010R, Suspension R1-R2 depths and P- and S_H-wave velocities

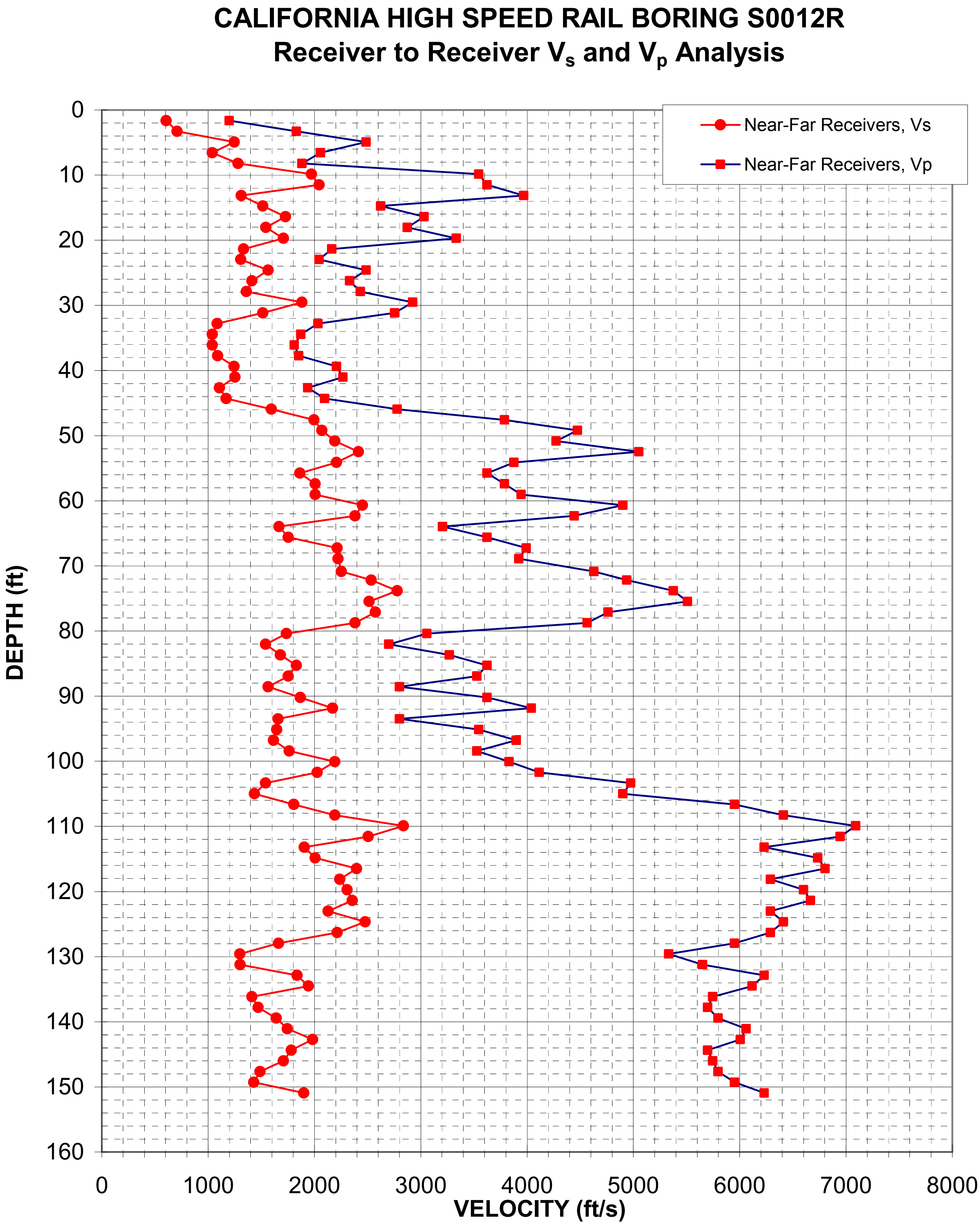

Figure 6: Boring S0012R, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
1.6	610	1200
3.3	710	1830
4.9	1250	2490
6.6	1040	2060
8.2	1280	1880
9.8	1970	3550
11.5	2040	3620
13.1	1310	3970
14.8	1520	2620
16.4	1730	3030
18.0	1540	2870
19.7	1710	3330
21.3	1330	2160
23.0	1310	2040
24.6	1560	2490
26.3	1410	2330
27.9	1360	2430
29.5	1880	2920
31.2	1520	2750
32.8	1090	2030
34.5	1040	1870
36.1	1040	1810
37.7	1090	1850
39.4	1240	2210
41.0	1250	2270
42.7	1110	1940
44.3	1170	2100
45.9	1590	2780
47.6	2000	3790
49.2	2070	4470
50.9	2190	4270
52.5	2420	5050
54.1	2210	3880
55.8	1860	3620
57.4	2010	3790
59.1	2010	3940
60.7	2450	4900
62.3	2380	4440
64.0	1670	3210
65.6	1750	3620
67.3	2210	3990
68.9	2220	3920
70.9	2250	4630
72.2	2530	4940
73.8	2780	5380
75.5	2520	5510
77.1	2570	4760
78.7	2380	4570
80.4	1740	3060
82.0	1540	2700
83.7	1680	3270
85.3	1830	3620
86.9	1750	3530
88.6	1560	2800
90.2	1870	3620
91.9	2170	4040
93.5	1660	2800
95.1	1650	3550
96.8	1610	3900
98.4	1760	3530
100.1	2190	3830
101.7	2030	4120
103.4	1540	4980
105.0	1440	4900
106.6	1810	5950
108.3	2190	6410
109.9	2840	7090
111.6	2510	6940
113.2	1900	6230
114.8	2010	6730
116.5	2400	6800
118.1	2240	6290
119.8	2310	6600
121.4	2360	6670
123.0	2130	6290
124.7	2480	6410
126.3	2210	6290
128.0	1660	5950
129.6	1300	5330
131.2	1300	5650
132.9	1840	6230
134.5	1940	6120
136.2	1410	5750
137.8	1470	5700
139.4	1640	5800
141.1	1750	6060
142.7	1980	6010
144.4	1780	5700
146.0	1710	5750
147.6	1490	5800
149.3	1430	5950
150.9	1900	6230

Table 5. Boring S0012R, Suspension R1-R2 depths and P- and S_H-wave velocities

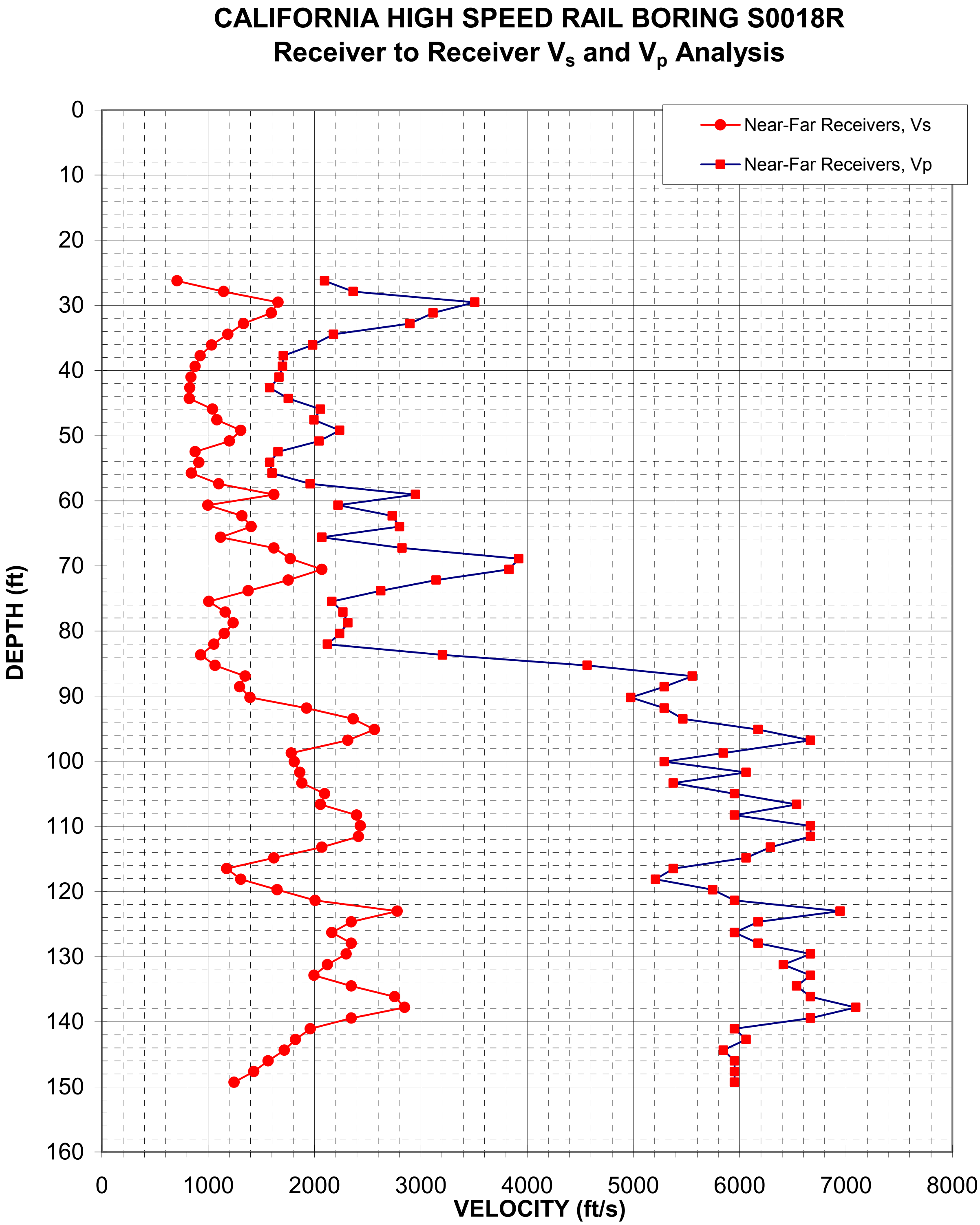

Figure 7: Boring S0018R, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
26.3	710	2100
27.9	1150	2360
29.5	1660	3510
31.2	1590	3120
32.8	1330	2900
34.5	1190	2180
36.1	1030	1980
37.7	930	1710
39.4	880	1700
41.0	840	1670
42.7	830	1580
44.3	820	1750
45.9	1040	2060
47.6	1080	2000
49.2	1310	2240
50.9	1200	2040
52.5	880	1660
54.1	910	1580
55.8	840	1600
57.4	1100	1960
59.1	1620	2950
60.7	1000	2220
62.3	1320	2730
64.0	1410	2800
65.6	1120	2070
67.3	1620	2820
68.9	1770	3920
70.5	2070	3830
72.2	1750	3140
73.8	1380	2620
75.5	1010	2160
77.1	1160	2270
78.7	1230	2310
80.4	1150	2240
82.0	1050	2120
83.7	930	3210
85.3	1060	4570
86.9	1350	5560
88.6	1300	5290
90.2	1390	4980
91.9	1930	5290
93.5	2360	5460
95.1	2560	6170
96.8	2310	6670
98.8	1780	5850
100.1	1810	5290
101.7	1860	6060
103.4	1880	5380
105.0	2100	5950
106.6	2060	6540
108.3	2400	5950
109.9	2430	6670
111.6	2420	6670
113.2	2070	6290
114.8	1620	6060
116.5	1170	5380
118.1	1310	5210
119.8	1650	5750
121.4	2010	5950
123.0	2780	6940
124.7	2350	6170
126.3	2160	5950
128.0	2350	6170
129.6	2300	6670
131.2	2120	6410
132.9	2000	6670
134.5	2350	6540
136.2	2750	6670
137.8	2850	7090
139.4	2350	6670
141.1	1960	5950
142.7	1820	6060
144.4	1720	5850
146.0	1560	5950
147.6	1430	5950
149.3	1240	5950

Table 6. Boring S0018R, Suspension R1-R2 depths and P- and S_H-wave velocities

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

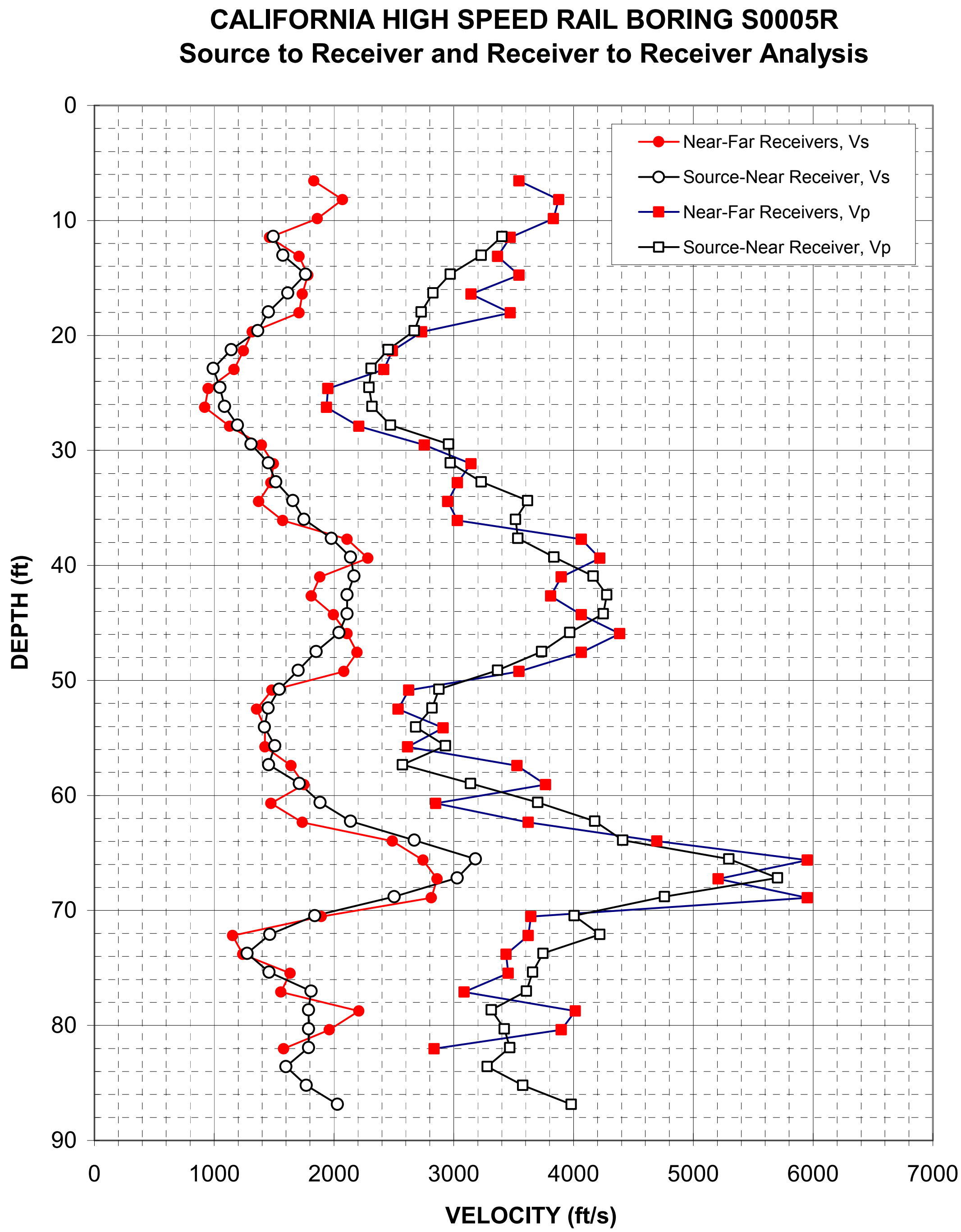

Figure A-1. Boring S0005R, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
11.4	1490	3400
13.0	1570	3230
14.7	1760	2970
16.3	1610	2830
18.0	1450	2730
19.6	1360	2670
21.2	1140	2450
22.9	990	2310
24.5	1050	2290
26.2	1090	2320
27.8	1190	2470
29.4	1310	2960
31.1	1450	2970
32.7	1510	3230
34.4	1660	3620
36.0	1750	3520
37.6	1980	3540
39.3	2140	3840
40.9	2170	4160
42.6	2110	4280
44.2	2110	4250
45.8	2040	3970
47.5	1850	3730
49.1	1700	3370
50.8	1540	2880
52.4	1450	2820
54.0	1420	2680
55.7	1510	2930
57.3	1460	2570
59.0	1710	3140
60.6	1880	3700
62.2	2140	4180
63.9	2670	4410
65.5	3180	5300
67.2	3030	5700
68.8	2500	4760
70.5	1840	4010
72.1	1470	4220
73.7	1280	3750
75.4	1460	3660
77.0	1810	3610
78.7	1790	3310
80.3	1790	3420
81.9	1790	3470
83.6	1600	3280
85.2	1770	3580
86.9	2030	3980

Table A-1. Boring S0005R, S - R1 quality assurance analysis P- and S_H-wave data

CALIFORNIA HIGH SPEED RAIL BORING S0010R
Source to Receiver and Receiver to Receiver Analysis

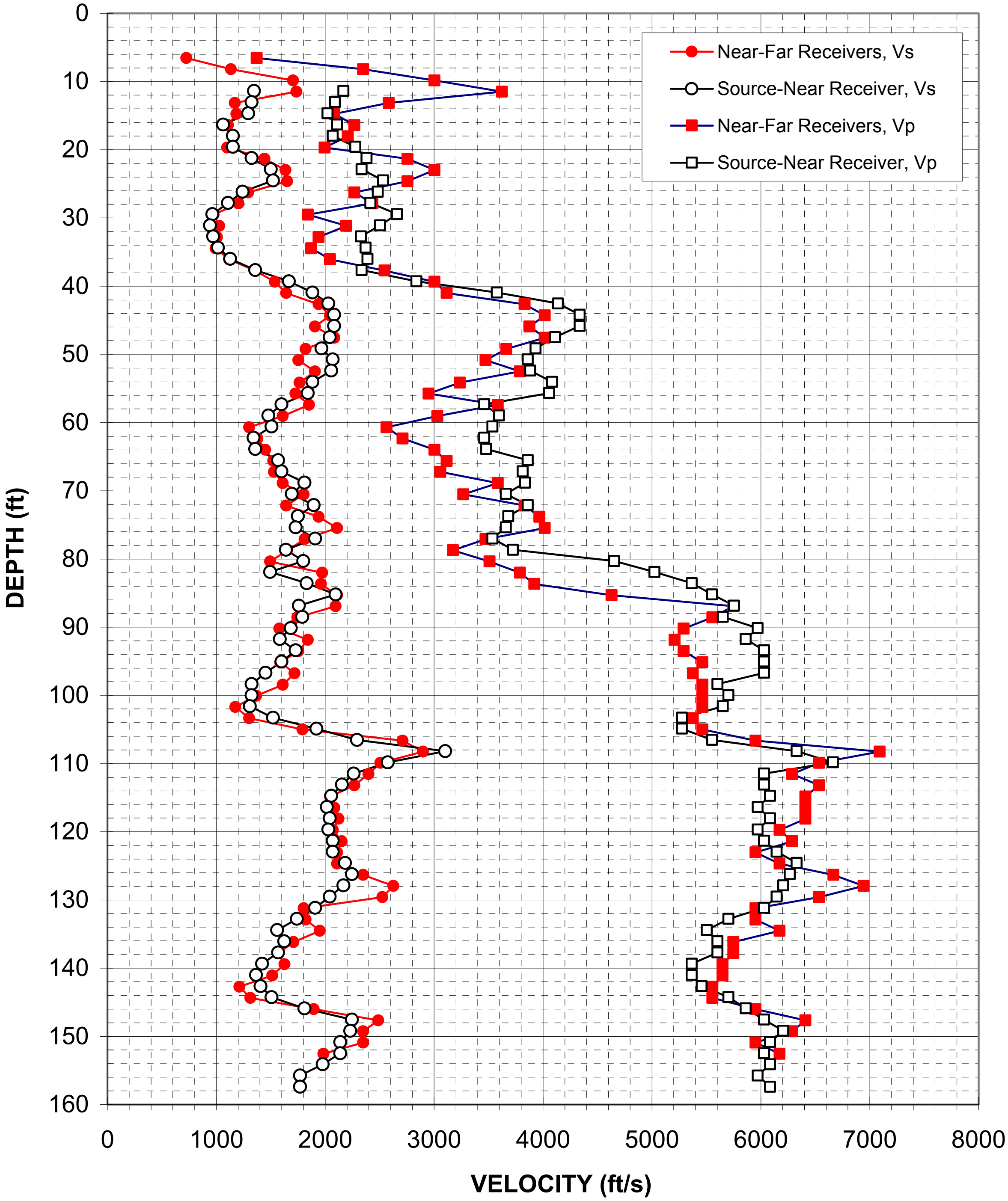

Figure A-2. Boring S0010R, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
11.4	1350	2170
13.0	1320	2090
14.7	1290	2020
16.3	1060	2110
18.0	1150	2070
19.6	1150	2280
21.2	1320	2380
22.9	1500	2340
24.5	1520	2530
26.2	1240	2480
27.8	1110	2420
29.4	960	2660
31.1	940	2500
32.7	970	2330
34.4	1010	2370
36.0	1130	2390
37.6	1360	2340
39.3	1670	2840
40.9	1880	3580
42.6	2030	4140
44.2	2080	4340
45.8	2080	4340
47.5	2040	4110
49.1	1970	3930
50.8	2070	3860
52.4	2060	3880
54.0	1880	4080
55.7	1840	4060
57.3	1600	3460
59.0	1480	3600
60.6	1510	3540
62.2	1340	3460
63.9	1360	3480
65.5	1570	3860
67.2	1600	3810
68.8	1810	3840
70.5	1690	3660
72.1	1900	3860
73.7	1750	3680
75.4	1730	3660
77.0	1910	3540
78.7	1640	3720
80.3	1800	4650
81.9	1490	5020
83.6	1830	5360
85.2	2100	5550
86.9	1760	5750
88.5	1790	5650
90.1	1680	5970
91.8	1580	5860
93.4	1730	6030
95.1	1600	6030
96.7	1450	6030
98.3	1320	5600
100.0	1320	5700
101.6	1310	5650
103.3	1520	5280
104.9	1920	5280
106.5	2290	5550
108.2	3100	6330
109.8	2570	6660
111.5	2260	6030
113.1	2150	6030
114.7	2060	6090
116.4	2020	5970
118.0	2040	6090
119.7	2030	5970
121.3	2070	6030
122.9	2070	6150
124.6	2180	6330
126.2	2240	6270
127.9	2170	6210
129.5	2040	6150
131.1	1910	6030
132.8	1740	5700
134.4	1560	5500
136.1	1620	5600
137.7	1570	5600
139.3	1420	5360
141.0	1360	5360
142.6	1410	5460
144.3	1510	5700
145.9	1810	5860
147.6	2240	6030
149.2	2230	6210
150.8	2140	6090
152.5	2140	6030
154.1	1980	6090
155.8	1770	5970
157.4	1770	6090

Table A-2. Boring S0010R, S - R1 quality assurance analysis P- and S_H-wave data

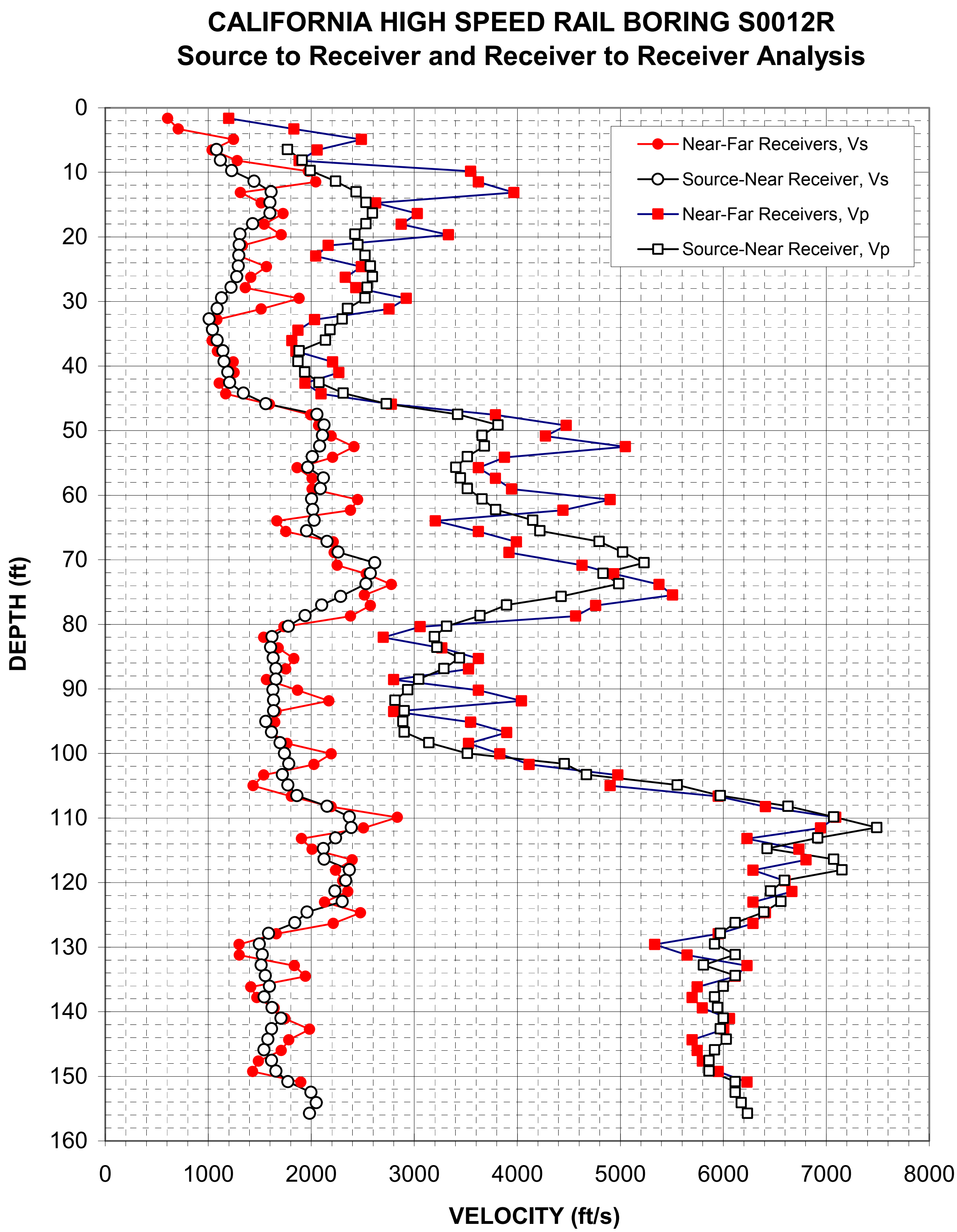

Figure A-3. Boring S0012R, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
6.5	1080	1770
8.1	1120	1910
9.8	1230	1990
11.4	1450	2240
13.0	1610	2430
14.7	1600	2530
16.3	1600	2590
18.0	1430	2530
19.6	1310	2430
21.2	1300	2450
22.9	1300	2520
24.5	1290	2570
26.2	1280	2590
27.8	1220	2540
29.4	1130	2520
31.1	1090	2350
32.7	1010	2300
34.4	1040	2180
36.0	1090	2140
37.6	1140	1880
39.3	1160	1870
40.9	1190	1940
42.6	1210	2080
44.2	1340	2310
45.8	1560	2730
47.5	2060	3420
49.1	2120	3810
50.8	2110	3660
52.4	2080	3680
54.0	2010	3520
55.7	1970	3400
57.3	2120	3450
59.0	2090	3520
60.6	2000	3660
62.2	2020	3790
63.9	2030	4150
65.5	1950	4220
67.2	2150	4800
68.8	2260	5020
70.5	2620	5230
72.1	2570	4830
73.7	2530	4980
75.7	2290	4430
77.0	2100	3900
78.7	1940	3640
80.3	1780	3310
81.9	1620	3200
83.6	1610	3220
85.2	1630	3440
86.9	1660	3290

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
88.5	1660	3040
90.1	1630	2940
91.8	1640	2810
93.4	1640	2900
95.1	1560	2890
96.7	1610	2900
98.3	1700	3140
100.0	1740	3520
101.6	1780	4460
103.3	1720	4670
104.9	1770	5550
106.5	1860	5970
108.2	2150	6630
109.8	2370	7070
111.5	2390	7490
113.1	2240	6920
114.7	2120	6430
116.4	2120	7070
118.0	2370	7150
119.7	2340	6590
121.3	2230	6460
122.9	2300	6560
124.6	1960	6390
126.2	1840	6120
127.9	1590	5970
129.5	1500	5920
131.1	1530	6120
132.8	1510	5810
134.4	1560	6120
136.1	1590	6000
137.7	1540	5920
139.3	1620	5940
141.0	1710	6000
142.6	1610	5970
144.3	1580	6030
145.9	1540	5920
147.6	1610	5860
149.2	1660	5860
150.8	1770	6120
152.5	2000	6120
154.1	2050	6180
155.8	1980	6240

Table A-3. Boring S0012R, S - R1 quality assurance analysis P- and S_H-wave data

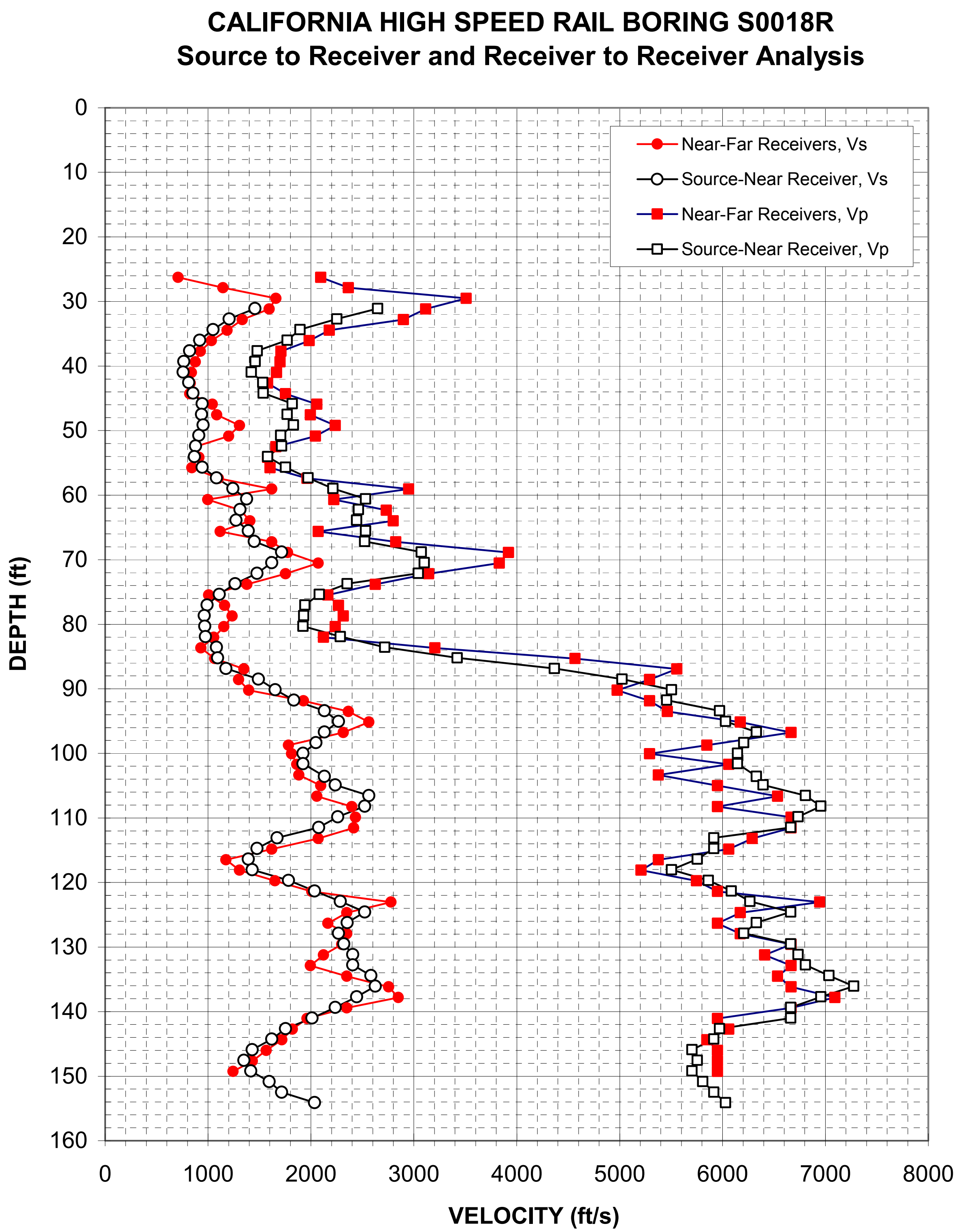

Figure A-4. Boring S0018R, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
31.1	1460	2650
32.7	1210	2250
34.4	1050	1900
36.0	920	1770
37.6	820	1480
39.3	760	1460
40.9	760	1420
42.6	810	1530
44.2	860	1540
45.8	940	1820
47.5	940	1770
49.1	950	1830
50.8	910	1710
52.4	880	1720
54.0	870	1580
55.7	940	1750
57.3	1080	1970
59.0	1240	2210
60.6	1380	2530
62.2	1310	2460
63.9	1270	2440
65.5	1390	2530
67.2	1450	2520
68.8	1720	3070
70.5	1620	3100
72.1	1480	3040
73.7	1260	2350
75.4	1110	2080
77.0	990	1940
78.7	960	1930
80.3	970	1920
81.9	980	2290
83.6	1080	2720
85.2	1090	3420
86.9	1170	4370
88.5	1490	5020
90.1	1650	5500
91.8	1830	5460
93.4	2130	5970
95.1	2270	6030
96.7	2130	6330
98.3	2050	6210
100.0	1920	6150
101.6	1920	6150
103.6	2130	6330
104.9	2240	6390
106.5	2560	6810
108.2	2520	6960
109.8	2260	6730
111.5	2080	6660

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
113.1	1670	5920
114.7	1480	5920
116.4	1390	5750
118.0	1430	5500
119.7	1780	5860
121.3	2040	6090
122.9	2290	6270
124.6	2520	6660
126.2	2350	6330
127.9	2270	6210
129.5	2320	6660
131.1	2410	6730
132.8	2410	6810
134.4	2580	7030
136.1	2630	7280
137.7	2440	6960
139.3	2240	6660
141.0	2010	6660
142.6	1750	5970
144.3	1620	5920
145.9	1430	5700
147.6	1350	5750
149.2	1420	5700
150.8	1590	5810
152.5	1720	5920
154.1	2040	6030

Table A-4. Boring S0018R, S - R1 quality assurance analysis P- and S_H-wave data

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION RECORDS

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

Certificate of Calibration

Date: 8/8/2011 ACCREDITED Lab # 935.11 **Certificate #: 1462196**

Customer:
GEOVISION
1124 OLYMPIC DRIVE
CORONA, CA, 92881

		Purchase Order:	BCHMPC2001001
		Work Order:	N/A
MPC Control #:	BG9698	Serial Number:	15014
Asset ID:	15014	Department:	N/A
Gage Type:	LOGGER	Performed By:	TYLER MCKEEN
Manufacturer:	OYO	Received Condition:	IN TOLERANCE
Model Number:	03331-0000	Returned Condition:	IN TOLERANCE
Size:	N/A	Cal Date:	July 22, 2011
Temp./RH:	70 °F / 35 %	Cal. Interval:	12 MONTHS
		Cal. Due Date:	July 22, 2012

Found conditions meet or exceed manufacturer specifications.

***Calibration Notes:**
This certificate superceeds 1443814.

See attached data sheet for calculations.
Calibrated IAW customer supplied calibration data form Rev 2.0

Test Points

Description	Standard	Tolerance -	Tolerance +	As Found	As Left	UOM	Result
Test Frequency	50.000	49.500	50.500	50.000	50.000	Hz	Pass
Test Frequency	100.000	99.000	101.000	100.000	100.000	Hz	Pass
Test Frequency	200.000	198.000	202.000	200.000	200.000	Hz	Pass
Test Frequency	500.000	495.000	505.000	500.000	500.000	Hz	Pass
Test Frequency	1000.000	990.000	1010.000	1000.000	1000.000	Hz	Pass
Test Frequency	2000.000	1980.000	2020.000	2000.000	2000.000	Hz	Pass

Standards Used To Calibrate Equipment

I.D.	Description	Model	Serial	Manufacturer	Cal. Due Date	Traceability #
AM4000	WAVEFORM GENERATOR	33250A	MY40000703	AGILENT	8/17/2011	1063979
CC8501	GPS TIME & FREQUENCY RECEIVER	58503A	3710A08295	HEWLETT PACKARD	1/31/2013	1269299

Calibrating Technician: TYLER MCKEEN

QC Approval: Jim Williams

Unless Otherwise Noted, Uncertainty Estimated at >= 4 to 1. Uncertainties have been estimated at a 95 percent confidence level (k=2). Services rendered comply with ISO 17025:2005, ISO 9001:2008, ANSI/NCSL Z540-3, MPC Quality Manual, MPC CSD and with customer purchase order instructions.

Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. The information on this report, pertains only to the instrument identified.

All standards are traceable to the National Institute of Standards and Technology (NIST). Services rendered include proper manufacturer's service instructions and are warranted for no less than thirty (30) days
This report may not be reproduced in part or in whole without the prior written approval of the issuing MPC lab.

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

Certificate of Calibration

Date: 8/8/2011 **Lab #** 935.11 **Certificate #: 1462196**

T1100	COUNTER	53131A	3546A09912	HEWLETT PACKARD	1/27/2012	1233372

Procedures Used In This Event:

Procedure Name	Description
CALIBRATION GENERAL	GENERAL CALIBRATION INSTRUCTION

Calibrating Technician: TYLER MCKEEN

QC Approval: Jim Williams

Unless Otherwise Noted, Uncertainty Estimated at >= 4 to 1. Uncertainties have been estimated at a 95 percent confidence level (k=2). Services rendered comply with ISO 17025:2005, ISO 9001:2008, ANSI/NCSL Z540-3, MPC Quality Manual, MPC CSD and with customer purchase order instructions.

Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. The information on this report, pertains only to the instrument identified.

All standards are traceable to the National Institute of Standards and Technology (NIST). Services rendered include proper manufacturer's service instructions and are warranted for no less than thirty (30) days This report may not be reproduced in part or in whole without the prior written approval of the issuing MPC lab.

BG 9698

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	OYO	Model no.:	3331
Serial no.:	15014	Calibration date:	7/22/2011
By:	Tyler McKeen	Due date:	7/22/2012
Counter mfg.:	Hewlett Packard	Model no.:	53131A
Serial no.:	3546A09912	Calibration date:	1/27/2011
By:	Micro Precision Calibration	Due date:	1/27/2012
Signal generator mfg.:	Hewlett Packard	Model no.:	33250A
Serial no.:	MY40000703	Calibration date:	8/17/2010
By:	Micro Precision Calibration	Due date:	8/17/2011

SYSTEM SETTINGS:

Gain:	20
Filter	LCF: 5Hz; HCF: 20kHz
Range:	See sample period in table below
Delay:	0 ms
Stack (1 std)	1
System date = correct date and time	7/22/2011 10:00

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10% As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.000	200	401	180.0	50.00	180.0	50.00	180.0	50.00
100.0	100.00	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.00	50	403	45.00	200.0	44.95	200.2	45.00	200.0
500.0	500.00	20	404	17.98	500.6	18.00	500.0	18.00	500.0
1000	1000.0	10	405	9.000	1000	9.000	1000	9.000	1000
2000	2000.0	5	406	4.500	2000	4.505	1998	4.500	2000

Calibrated by:	Tyler McKeen	7/22/2011	
	Name	Date	Signature
Witnessed by:	Robert Steller	7/22/2011	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008